Twenty Two Years of Environmental Surveillance at Centro Experimental Aramar

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Abstract. A brief description of the Environmental Surveillance Program conducted at the Centro Experimental Aramar is presented. Results of the surveillance program over the last twenty two years are presented for selected environmental matrices. The results indicate that no environmental radiological impact has yet been detected in the environs of the CEA site.

1. INTRODUCTION

Since 1988, CTMSP - Centro Tecnológico da Marinha em São Paulo – maintains a comprehensive environmental surveillance program at CEA - Centro Experimental Arama. CEA is a major nuclear research center responsible for the development of nuclear tecnology in Brazil. The nuclear installations today in operation at the CEA site are two enrichment plants and a nuclear material laboratory. In the near future CEA a uranium hexafluoride production plant will start operation. A 48 Mwth prototipe pressurized water reactor is also under construction at the CEA site. This reactor is expected to enter operation around 2014.

The present CEA Environmental Surveillance Program (ESP) encompasses radiological and non radiological survey of an area of about 10 km radius around the site. The purpose of the ESP program is to monitor the various pathways by which the environment and the public could be exposed to radioactive and non radioactive contaminants released from CEA. Atmospheric, terrestrial, aquatic and direct radiation pathways are monitored. Routine sampling of foodstuffs (milk, beans, etc), botton sediments, soils, fish, air, surface and underground water sources are performed.The present radiological surveillance program includes measurements of the naturally occurring radionuclides of the U^{238} and Th^{232} series, which are the potential components of liquid and gaseous effluents released to the environment from nuclear fuel cycle facilities in operation at the CEA site. The non radiological monitoring program consists of assessing ground water and surface water quality.

The Environmental Surveillance Program conducted by CTMSP must comply with the regulatory standards of the Brazilian National Nuclear Energy Commission (CNEN) which is responsible for conducting the licensing process for nuclear installations in Brazil. The ESP program must also comply with the regulatory standards of the Brazilian Environmental Protection Agency (IBAMA).

This paper presents a brief description of the Environmental Surveillance Program set up by CTMSP. Results obtained from the ESP program over the last twenty two years of environmental surveillance are presented for selected environmental matrices. The results indicate that no environmental radiological impact has yet been detected in the environs of the CEA site.

2. GENERAL SITE INFORMATION

The CEA is situated in the State of São Paulo, Brazil, at a distance of about 130 km North West of the capital city of São Paulo. The site is located in a rural area about 10 km from the town of Iperó. The CEA site is comprised of 8.5 km^2 extending for about 5 km along a municipal road that links the town of Sorocaba to Iperó. These two cities are the largest surrounding urban areas in the environs of CEA.

The surrounding area of CEA is characterized by the presence of a few farms and a large number of small rural properties. Orange production is the main large scale farming activity found in the area. Small properties produce beans, corn, and milk mainly for their own consumption. Meat and poultry can also be found for local consumption. No commercial fishing activities are found in the region. Fish is caught mainly for local consumption and recreational purposes

A large part of CEA is still covered by natural vegetation. The developed area is concentrated at north side of the site as shown on Figure 1.The CEA site is bounded in its south side by FLONA (National Ipanema Forest), a national environmental protection area. This area is a transition region between seasonal semi deciduous Forest and Savannah Forest (Cerrado). The existing vegetation of CEA and FLONA provide habitat for birds and small animals.

The site is crossed by the Ipanema River and Ferro Stream. These two rivers are tributaries of the Sorocaba River, which flows west-ward through the northern part of CEA at about 4 km from the site. The Ipanema River provides the water needed to operate the nuclear and conventional installations at the CEA site. The Ipanema River is classified by the Brazilian Environmental Protection Agency (IBAMA) as a Class-2 river. Liquid effluent releases in Class-2 Rivers must be in compliance with the applicable CONAMA regulations to ensure that adequate water quality is kept unaltered [1].

The nuclear facilities today in operation at the CEA site are two enrichment plants and a laboratory for development of nuclear fuels. In final stage of construction is a uranium hexafluoride production plant expected to start operation by 2011. In initial stage of construction is a 48MW thermal pressurized water reactor. This reactor is intended to serve as a test bed for developing the capability to design small and medium power reactors for electricity production, and for nuclear propulsion.

Figure 1: Centro Experimental Aramar – CEA (Photo from Google Earth)

3. ENVIRONMENTAL SURVEILLANCE PROGRAM -CEA

The present Environmental Surveillance Program (ESP) encompasses radiological and non radiological surveillance within an area of about 10 km around the CEA site. The purpose of the ESP is to survey the various pathways by which the environment and the public could be exposed to radioactive and non radioactive contaminants. Atmospheric, terrestrial, aquatic and direct radiation pathways are surveyed. Routine sampling of foodstuffs (milk, beans, orange, etc), bottom sediments, soils, fish, air, surface water, ground water and rain water sources are performed. The non radiological surveillance program consists of assessing surface water, rain water and ground water quality. Ambient air is analised for gamma emiters radionuclides, uranium and for fluorides.

Samples are collected from selected onsite and offsite sampling locations as shown in Fig 2. There are 53 sampling locations about half of which are located inside the boundaries of CEA. Annually, about 1000 samples are collected from the environment and sent for analysis to the Radioecological Laboratory (LARE), an environmental laboratory operated by CEA.

The present radiological monitoring program includes measurements of the naturally occurring radionuclides of the U^{238} and Th^{232} decay series.These radionuclides are expected to be present in the liquid and gaseous effluents released to the environment from the front end nuclear fuel cycle facilities in operation at CEA.

Fluorimetry is used to determine the total uranium concentration (the sum of U^{234}, U^{235}, and U^{238}) in the environmental samples collected. High resolution gamma spectrometry, using high purity germanium detectors, is used to detect gamma emitting radionuclides of the U^{238} and Th^{232} decay series. Fluorimetry and gamma ray spectrometry are performed in all environmental matrices defined in the ESP program.

Thermo luminescent dosimeters (TLD) are used to measure external radiation at the CEA site and its environs. TLDs are located at 27 sampling stations and positioned appoximately 1 meter above the ground.They are collected and read quartely. A control station is located at the town of Sarapui, about 45 km from the CEA site.

The non radiological surveillance program for surface water includes measurements of chemical and biological indicators of water quality. The surface water bodies monitored include the Ipanema River, Ferro Stream and the Sorocaba River. The program includes measurements of pH, electrical conductivity, BOD, COD, chloride and nitrite, hexavalent chromium, total phosphate, Orthophosphate, Manganese, Nickel, Ammonia, Potassium, Zinc, Turbidity, Iron, DO, Colour, Chromium, Sodium, Total solids, Cadmium, Lead, Total Coliforms and Fecal Coliforms.

Ground water surveillance includes measurements of fluorides, pH, electrical conductivity, Sodium and Potassium. Three wells are monitored semiannually. One well is located at the CEA site and the other two at locations situated about 5 km from the site.

Rain water radiological surveillance includes measurements of gamma emiters radionuclides and total uranium concentration. Non radiological surveillance includes measurements of. pH, fluorides, Sodium and Potassium.Rain water is collected in the first day after rain stopped .

Continuous particulate air samples are collected from six locations using high-volume air samplers located in the prevailing downwind direction.Three locations are used for fluoride measurements, and samples are collected weekly. The other three locations are used to detect gamma emiters and total uranium concentration in ambient air. Samples are collected and read montly.

Samples of agricultural products are collected routinely at the harvest time. The samples are analized for radionuclides and total uranium. Beans, orange are analized.

The region around CEA is not a commercially milk producing area. Milk is produced by the farmers only for their own consumption. Raw unprocessed milk samples are collected semiannually from the few milk producers in the area.

Table 1 summarizes the media monitored, the number of sampling stations for each media, the frequency of sampling and the type of analyses performed.

The Environmental Surveillance Program conducted by CTMSP must comply with the regulatory standards of the Brazilian National Nuclear Energy Commission (CNEN) which is responsible for conducting the licensing process for nuclear installations in Brazil. The ESP program must also comply with the regulatory standards of the Brazilian Environmental Protection Agency (IBAMA).

The Environmental Surveillance Program is suplemented by an Effluent Monitoring Program (EMP) as required by CNEN and IBAMA. The EMP program consists of monitoring liquid effluent and airborne emissions that may contain radioactive or hazardous materials. Samples are collected at points of release into the environment and sent for analysis to LARE.

Results of the ESP program provide valuable information on the effectiveness of CEA liquid and airborne effluents controls set up by the EMP program. As required by the Regulators, the results of the environmental surveillance and of the environmental releases of radioactive materials and hazardous materials from CEA are reported to CNEN and IBAMA through annual and semmiannual reports.

Figure 2: CEA Onsite and Off Site Environmental Sampling Locations

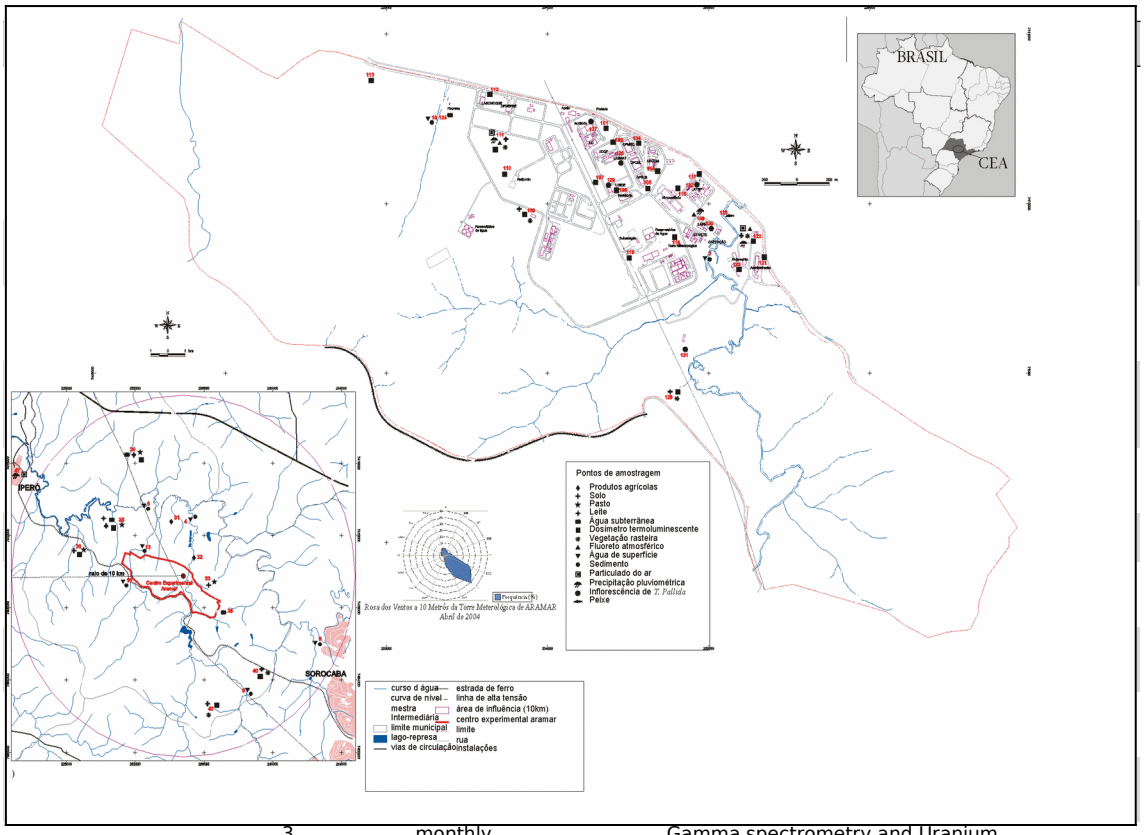

Table 1: CEA Environmental Surveillance Program

Air	3 3	monthly weekly	Gamma spectrometry and Uranium Fluoride

4. RESULTS

The results of 22 years of Environmental Surveillance Program at CEA are summarized below for selected matrices and sampling points. In general the results are consistent with those reported in the pre-operational phase. The pre-operational program was performed by the Instituto de Pesquisas Energéticas e Nucleares (IPEN-CNEN/SP). A detailed description of this program and the results covering the years of 1987 and 1988 can be found in IPEN-CNEN/SP Reports [2]and [3], available at the internet. Since 1989, the operational monitoring program is being performed by the Laboratório Radioecológico -LARE located at the CEA site.

4.1 Radiological Surveillance

The pre-operational radiological surveillance program for surface water, ground water, and rain water produced results that are all below the detection limits[2]. The program covered total uranium, radionuclides of Th^{232}, and U^{235}, decay series, K^{40}, and Be^{7}. The operational surveillance program showed similar results. Gamma emitters and total uranium were found only occasionally in surface water samples, even so the concentrations found were close to the detection limits. Gamma emitters and total uranium were occasionally found in agricultural products, fish, milk, pasture and vegetation. Table 2 shows the maximum concentrations of total uranium found in some of the environmental matrices covered by the program.

Table 2: Maximum Concentration Total Uranium in Selected Matrices (Bq/Kg)

Product	Year	Sampling Location	Max Con. (Bq/Kg)
Beans	1987	126	45 ±12.5
Orange	1988	32	75±22.5
Potato	1987	31	22,5±7,5
Fish	1988	5	37.5±12.5
Corn	1987	126	32,5±10
Corn	1988	45	27,5±7,5

Total uranium and gamma emitters were detected in river bottom sediments and soil samples. Sediments are collected along Ipanema River, upstream and downstream CEA liquid effluent discharge point. Figure 3 shows the results for three sampling points (Point 2 is located at the liquid effluent discharge point; Point 4 is about 4.5 kms downstream, and Point 8 is about 8.5 kms upstream).

Soil and pasture samples are collected semiannually from twelve locations onsite and offsite CEA. Gamma emitters were occasionally detected in pasture. The soil annual average concentration of total uranium is shown in Figure 4 for two sampling points (Points 39 located about 7.5 kms northwest CEA; and Point 40 located about 7.5 kms southeast CEA).

External gamma exposure in air is assessed by using a network of thermoluminescent dosimeters (TLDs) at 27 fixed locations. Figure 5 shows the results for three selected points (39 - offsite about 7.5kms north of CEA; Point 35 - offsite about 5kms from CEA; and Point 43- Blank about 54kms from CEA in the town of Sarapui).

4.2 Non Radiological Surveillance

The non radiological surveillance program for surface water includes measurements of chemical and biological indicators of water quality in the Sorocaba and Ipanema Rivers and Ferro Stream.

In the past, the Sorocaba River received untreated industrial effluents produced in the cities of Sorocaba and Ipero. This has now changed due to more stringent environmental regulations. However, the Sorocaba River still receives domestic pollutants. Farming activities are also an additional source of pollutants such as fertilizers, insecticides, and other chemicals used by the farming community in the area.

The Ipanema River and Ferro stream are more preserved than the Sorocaba River. In both rivers, the overall quality of surface water is good and in compliance with the standards established by the environmental legislation for Class 2 river[1].

The Sorocaba River, compared to the Ipanema River and Ferro Stream, has higher concentrations of organic contaminants; higher DBOs; higher ammonia concentration; and a lower concentration of dissolved oxigen.This is shown in Figures 6, 7 and 8. Nitrates concentration are shown in Figure 10.

The region surrounding the CEA site is known to have relatively high concentrations of iron in surface waters, due to the presence of iron reserves in the region. The results for iron is shown in Figure 9

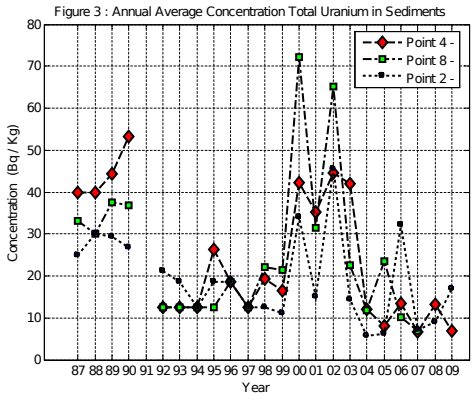
Figure 3 : Annual Average Concentration Total Uranium in Sediments
Point 4 -
Point 8 -
Point 2 -
Concentration (Bq / Kg)
Year

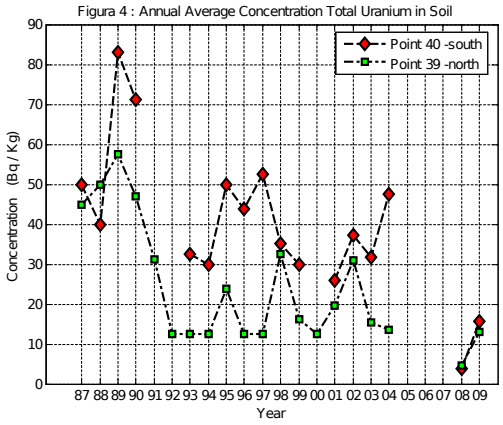
Figura 4 : Annual Average Concentration Total Uranium in Soil
Point 40 -south
Point 39 -north
Concentration (Bq / Kg)
Year

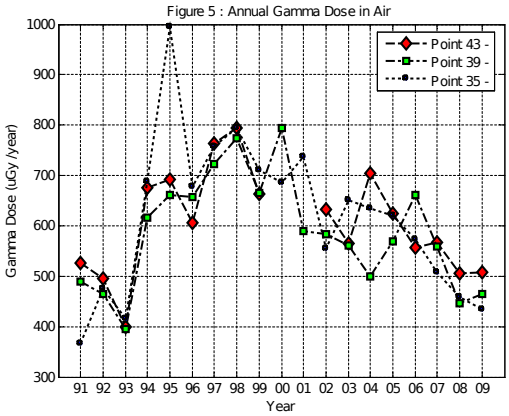
Figure 5 : Annual Gamma Dose in Air
Point 43 -
Point 39 -
Point 35 -
Gamma Dose (uGy /year)
Year

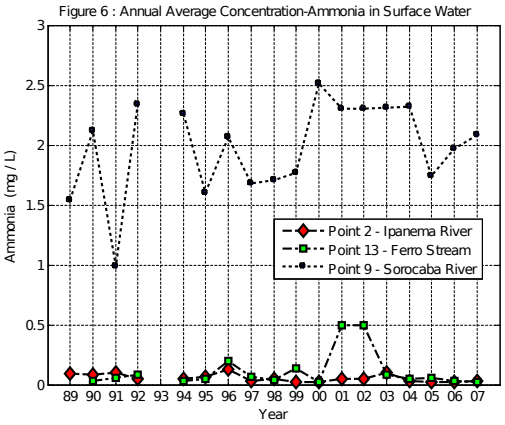
Figure 6 : Annual Average Concentration-Ammonia in Surface Water
Point 2 - Ipanema River
Point 13 - Ferro Stream
Point 9 - Sorocaba River
Ammonia (mg / L)
Year

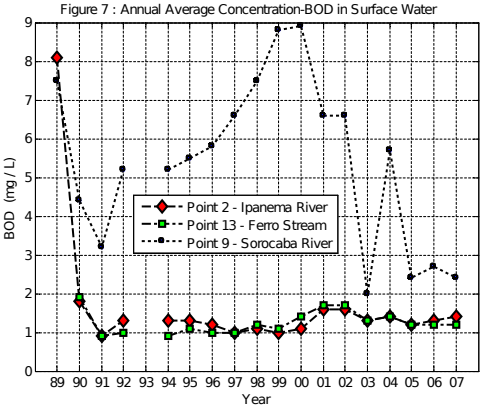
Figure 7 : Annual Average Concentration-BOD in Surface Water
Point 2 - Ipanema River
Point 13 - Ferro Stream
Point 9 - Sorocaba River
BOD (mg / L)
Year

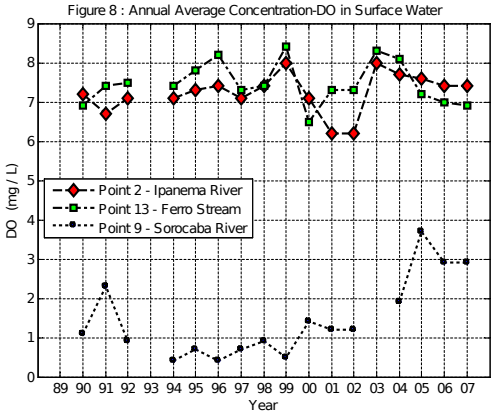
Figure 8 : Annual Average Concentration-DO in Surface Water
Point 2 - Ipanema River
Point 13 - Ferro Stream
Point 9 - Sorocaba River
DO (mg / L)
Year

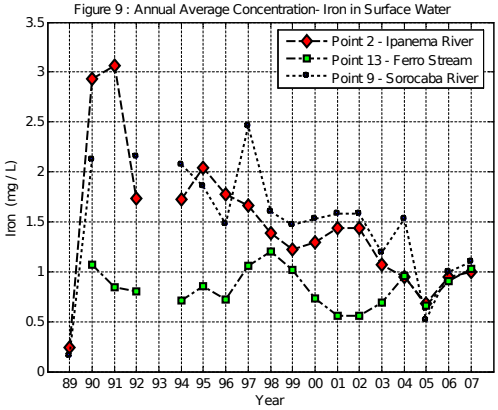
Figure 9 : Annual Average Concentration- Iron in Surface Water
Point 2 - Ipanema River
Point 13 - Ferro Stream
Point 9 - Sorocaba River
Iron (mg / L)
Year

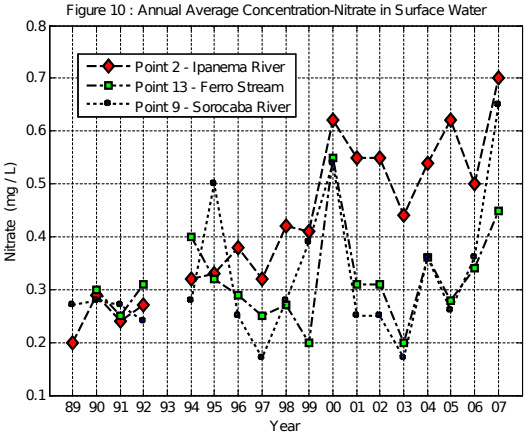
Figure 10 : Annual Average Concentration-Nitrate in Surface Water
Point 2 - Ipanema River
Point 13 - Ferro Stream
Point 9 - Sorocaba River
Nitrate (mg / L)
Year

Acknowledgements

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